TROPICAL AGRICULTURE

THE OFFICIAL JOURNAL OF THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

VOL. XVII, No. 11. NOVEMBER, 1940. PRICE 6d.

CONTENTS.

	PAGE.
The College Journal	201
Mosquito Repellents	202
The Case for Long Range Research in Cacao Production	203
Progress in Sugar-Cane Agriculture in Antigua during the period 1933-1940 ...	208
Lasting Effects of Molasses as a Fertiliser...	212
Cultivation of Bananas under Shade for the Control of Leaf Spot Disease	213
Control of Pineapple Caterpillar	215
The Chemical Composition of the Hen's Egg	217
Miscellaneous Notes	219
Chemical Notes	220

THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

Cables :: "Stomata." | Phone :: 2183

TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, Broadway Bldgs., Westminster, S.W. 1, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

THE COLLEGE JOURNAL.

WE believe we can reasonably claim that there has not been any fundamental change in the policy of this Journal since it was first published in 1924. Its main object during the past 17 years has been to keep its readers in touch with the progress of agricultural research in the tropics and to stress the importance of tropical agriculture in relation to the development of our Colonial Empire. Much valuable material has been accumulated and practically every aspect of tropical agriculture may be said to have been dealt with. Technical and popular articles have appeared on such diverse topics as crop and animal husbandry, pests and diseases, soil chemistry, the use of fertilizers, the manufacture of crop products, field experiments, plant breeding, genetics, statistical methods, storage problems, general agricultural policy, agricultural education, tropical land tenure and forestry. Prominence has necessarily been given to tropical crops although most attention in this field has been given to cacao, sugar-cane, bananas, tropical fruits and vegetables. Whenever possible the opportunity has been taken to present the latest discoveries of research not only at the Imperial College of Tropical Agriculture but also in other parts of the tropics. Many scientific works in tropical agriculture have been reviewed and the more important papers in the sphere of agricultural science and sugar technology summarised. From time to time also, information has been recorded relating to the progress of West Indian agriculture. In short we have attempted to keep our readers as well informed as possible of recent developments in tropical agriculture not only in the West Indies but also in the Colonial Empire.

As can be imagined it has not always been possible for us to satisfy the needs of all our classes of readers. Since we began publishing original research we have been told by some that we were getting too technical and by others that we were not technical enough. This criticism was of course inevitable when it is remembered that our readers not only comprise agricultural officers and scientific workers but also planters, business men, Government officials and ordinary laymen. Since the majority of our readers, however, consists of officers engaged in an administrative or advisory capacity in agriculture, we have recently decided that our most appropriate policy would be to attempt, in the first place, to satisfy their requirements. Such officers do not generally see many

recognised scientific periodicals nor would they have time to read them even if they were able to see them. Most, however, do see and read our Journal. This consideration thus gives us quite a wide field: for it is desirable that such officers should read, and such officers desire to read, articles dealing with the agricultural sciences, provided that the articles have a fairly direct bearing upon, or have an interest in connection with, their work as agriculturists. It seems pretty certain too that what is likely to interest them is also likely to be, in some measure, of interest to those planters and laymen who wish to keep themselves well informed of the latest results of agricultural research. In future, therefore, when selecting an article we shall primarily consider whether it will be of use or of interest to the type of officer mentioned. We propose as hitherto to continue to be the recognised medium for the publication of articles on current work submitted by officers of the College and, to a lesser degree, of the Trinidad Department of Agriculture. Any papers of a very specialised nature are to be ruled out, although a little more latitude in this respect has to be permitted in the case of articles by College officers, particularly in cases where prompt publication is for some reason necessary. Even for them, however, too much latitude is not desirable, nor will it be necessary, since the type of papers which will be ruled out as being too technical will be published in some recognised scientific journal issued by a specialised central institution or society in England or America. Articles bearing purely on local problems in Trinidad must also be rejected unless they are likely to be of wider interest, as, of course, such papers often are. We shall continue to welcome articles of a general character which, although containing nothing new, are of a critical nature. Reviews, summaries and abstracts calling attention to work accomplished in other countries will always be of particular interest to us since they provide the very information which is wanted by our readers. This kind of article, incidentally, is one of the most difficult to write and not easy to obtain: we should appreciate any assistance which outside contributors may care to give us in this direction.

We shall continue from time to time to reprint important articles published in periodicals which are unlikely to get into the hands of agricultural officers. The general practice followed by the bigger departments of agriculture is to subscribe to several copies of periodicals which are likely to be particularly useful to their officers and to take only one copy of those periodicals which are less often interesting to them. There are, in addition, many periodicals which never find their way into agricultural departmental libraries. A large department might, for instance, subscribe to several copies of the *Empire Journal of Experimental Agriculture* or of the *Bulletin of the Imperial Institute* in order that most of its staff may have a reasonable chance of seeing these publications. It may, on the other hand, subscribe to only one copy of *Nature* or of the *Journal of Agricultural Science*, and not subscribe at all to such periodicals as *Chemical Abstracts* or *The Bulletin of the Colonial Institute, Amsterdam*. When reprinting or summarizing we accordingly pay especial attention to articles of possible interest to our readers which appear in those journals to which departments of agriculture are less likely to subscribe. In this way it is believed a useful service will be rendered to those who wish to keep up to date with current literature on tropical agriculture.

We have felt for some time the need for defining our policy a little more clearly and we hope that enough has been said to show our readers what our aims are. We believe that through this policy the contents of *Tropical Agriculture* will be of a nature that will appeal to our largest number of readers. Every endeavour will be made to supply information in a form which can be easily assimilated so as to keep our readers interested in the progress of research and to assist them in their efforts to improve farming methods in the tropics.

MOSQUITO REPELLENTS.

The results of a study, begun in 1935 of chemicals for possible mosquito repellent properties are published in an article by P. Granett in the *Journal of Economic Entomology*, Vol. XXXIII, No. 3. According to this article a repellent product has been developed consisting of diethylene glycol monobutyl ether acetate, diethylene glycol monoethyl ether, ethyl alcohol, corn oil, and perfume.

Comparative tests with nearly 1,000 materials show that this mixture is definitely superior as a mosquito repellent to any of the usable available chemicals, and mixtures of them, which were tested. This mixture was also definitely superior to the 42 representative proprietary products tested. In the chemical group, the runner-up was the familiar repellent, oil of citronella.

This newly developed repellent is on equal terms with others as regards its undesirable solvent action on certain organic materials. Experience of users clearly indicates, however, that they do not consider this property a serious drawback.

This repellent product was also found superior in its combination of accessory properties such as pleasing odour, lack of irritation, toxic effects or unsightly appearance when applied to normal skin and its harmlessness to all fabrics except acetate rayon.

In tests against blood sucking pests other than mosquitoes, such as black flies, sand flies, stable flies, deer flies and chiggers, more frequent applications of this new repellent are necessary to obtain satisfactory relief from annoyance. In general, however, it has the same relative order of superiority over other chemicals and proprietaries for these pests as it has for mosquitoes.

THE CASE FOR LONG RANGE RESEARCH IN CACAO PRODUCTION.

By E. E. Cheesman.*

The annual world production of cacao is about 500,000 tons and in most industries of such a size the need for continuous scientific research is nowadays unquestioned. In this particular branch of tropical agriculture, however, a certain type of research has only recently been started, and though its usefulness is admitted in general terms, few people yet appreciate how much it is needed, or how great are the services it can render.

The type of research described as "long-range" is concerned more with the acquisition of generally useful information than with the solution of specific practical problems. That is not to say that it seeks knowledge without regard to applications, but rather that it seeks a knowledge of the principles upon which practical improvements will be based. Specific problems are often local in their importance, and can best be solved by local research, of which a considerable volume goes on in the cacao-growing industry. The rôle of long-range research is not to replace local investigation but to help it to a quicker solution of its problems, in much the same way as fundamental medical research helps the busy practitioner to cure his patients.

Whilst its full results can only be obtained by continuous effort over a period of years, long-range research also produces valuable interim results which may be immediately applied with profit to the industry. It is hoped that this account of what has been done and what is proposed for the future will show that results of practical significance have in fact already been achieved in the cacao research work of the Imperial College of Tropical Agriculture.

Ten Years' Results.

The Cacao Research Scheme at the Imperial College of Tropical Agriculture was launched in 1930, and although it was not the beginning of research into cacao it represented the first organized attack on long-range problems of the crop, and provided for the first time a staff free to devote its whole time to them.

The start was on a modest scale, and the staff comprised two botanists (since reduced to one) and one chemist, working under the direction of the Professors of Botany and Chemistry in the Imperial College. Within the College organization, however, these officers had the benefits of contact and co-operation with a scientific team, many members of which were already (and are still) working on the same crop, although not included in the Scheme. Finance was provided jointly by the cacao-growing countries of the Empire and leading English chocolate firms, and this co-operation of producers and manufacturers facilitated the adoption of broad aims.

From its nature, long-range research can conveniently be concentrated on a central station and still serve a number of countries; and for a central station dealing with cacao, Trinidad offers many advantages. There is a wider range of variation in its cacao tree population than in any of the larger producing countries, and at the same time the island presents an extraordinary variety of soils and of climatic and topographical conditions in small compass. Incidentally it is conveniently near to the original home of cacao, and so well placed for receiving new introductions for study. The research workers are brought into contact with practical planters, sympathetic to research and willing to help, and are thus kept fully aware of the economic conditions that will ultimately govern the application of their results. Furthermore, there is local research in progress, and co-operation between the officers engaged in it and those on the central station, each keeping as far as possible within his own sphere, benefits both.

The botanical section started with a quantitative survey of Trinidad cacao. It was known that the tree population was very much mixed, but there was no precise knowledge of the range of variability, and the figures obtained in the first two years were illuminating. Among them an outstanding result was the demonstration that one pod of a good type of tree may contain as much cacao as five pods of a poor type, and that the product in the former case is of much better quality. The simple broad generalization was established for a wide range of different types of cacao that the number of beans in different sized mature pods is roughly constant lying generally between 30 and 40 and most commonly not far from 35. The individual beans of different trees on the other hand vary much in size. Thus it comes about that a pod with large beans always yields a large weight of cacao from each pod; and *vice versa*. Thus, so far as concerns those attributes of quality which are associated with large beans there is not, in cacao, that antithesis between quantity and quality that is the eternal bugbear of the plant breeders of many crops.

The figures obtained in the survey were combined with certain records of variability in terms of pods per tree, which had been obtained earlier by the Trinidad Department of Agriculture; and it then became possible to calculate the yielding capabilities of the most efficient trees in the population, and to set standards for selection of such trees. By the end of 1935, one hundred trees had been selected which were far above the Trinidad average, and experiments were planned to compare them and re-select the most useful.

* Professor F. Hardy has supplied the substance of all the paragraphs dealing with chemical and ecological work, which is under his direction. I am indebted to him, to the other Cacao Research Officers, and to other members of the Imperial College staff for co-operation in the preparation of this account of what is essentially team work. (E. E. C.)

Meanwhile attention had been given to the question of propagation. All horticultural experience suggested that some form of vegetative propagation was desirable if the good qualities of selected trees were to be preserved in their progeny. The method of budding on seedling stocks was available, but seedling stocks are themselves variable, and in order to obtain absolutely uniform progenies recourse must be had to the rooting of cuttings. A technique for this purpose was quickly found, and gradually improved, and by 1935 was established as a practicable process ready to be used for the new selections. The first cuttings rooted are now more than five years old, and appear quite satisfactory both in habit and root system. Cuttings of selected types have begun to bear as early as two years old under estate conditions, and at three years old one clone has yielded an average of 2 lb. of cacao per tree.

The next step was to lay down field experiments designed to answer several questions such as (1) Which of the 100 selected trees will give the most profitable progeny ? (2) In multiplying selected types, what is the advantage of vegetative over seedling propagation ? (3) If vegetative propagation is the better, should it be done by budding or by rooting cuttings ? (4) Which is the better type of budwood or cutting to be used for propagation, that which gives a tree with a main trunk or that which gives a low-branching tree of bushy habit ? Material for such experiments was propagated ; and in 1937, 600 young trees were set out in the first of a comprehensive series of field trials, the planting of which is continuing and will occupy several years. Differences in behaviour between clones are already apparent, especially in earliness of bearing, and useful information is thus beginning to come in even at this early stage.

Concurrently with these researches, investigations had been made into the behaviour of individual trees in building up their crop. Along this line the most interesting discovery was that self-incompatibility occurs in cacao, which means that some trees will set no fruit with their own pollen, but must always be cross-fertilized if they are to give a crop. It was found that Trinidad cacao trees could be divided into two classes, those which will set fruit with their own pollen (self-compatible) and those which will not (self-incompatible). The latter must be pollinated from self-compatible trees before they set fruit ; and further study indicated fairly clearly that, although under some conditions self-incompatible trees may be heavy yielders, under other conditions their presence in the field may be one of the many causes of low yields. Later, it was shown that, although the division into two classes is sharp enough for practical purposes, there are degrees of self-compatibility, and even essentially incompatible trees will very occasionally set fruit by their own pollen. Quite recently the mechanism of incompatibility in cacao has been studied, and found to be different from that known in temperate fruit trees. Further research into the connection between incompatibility and low yield is proceeding.

All these botanical researches are based on the certainty that one method of improving yield and quality is to substitute better trees for those now grown, and together they constitute an attempt to provide trees of the right kind and, above all, to establish the methods by which better trees can be sought, found, and propagated in all cacao-growing countries. But it has not been forgotten that there are other ways of improving yield and quality, nor that the existing cacao-tree population must supply the markets for many years to come, since replacement can only be gradual, even when all the necessary knowledge and material are available. For these reasons, researches into botanical constitution were from the beginning coupled with investigations of the environment in which the tree grows, including the agricultural treatment it receives.

Investigations in cacao ecology occupied most of the time of the Chemical Section during the first five years of the scheme. The main idea was to determine experimentally what constitutes a good physical and chemical environment for cacao. In Trinidad, all stages of adjustment and maladjustment of the cacao tree to its environment are evident ; the soil types are very varied, the topography and climate differ considerably in different cacao-growing districts, and the methods of cultivation and age of the trees vary widely. Moreover, it is possible to gauge the yielding capacity of the tree in different parts of the Island by the field records kept by managers, and the analysis of yield-data made by Professor Shephard (of the College Department of Economics) has demonstrated a high degree of correlation between soil-type and profitableness of cacao.

In order to identify a "good" cacao environment, two methods were employed, namely, (1) the periodic assessment of all the soil and atmospheric factors that could be measured by soil analysis and by means of standard meteorological instruments set up in two contrasted "good" and "bad" plots, and (2) detailed soil surveys of established cacao areas, by means of which high-yielding soil-types could be delineated and their main features identified by laboratory analysis of representative soil samples. The main conclusions reached are summarised in detail in the Fifth Annual Report. A close relationship was shown to exist between physiological activities (*e.g.*, leaf-flush, flowering, fruit-setting, wilting, shedding, &c.) and the fluctuations in the moisture status of both soil and atmosphere. A "good" cacao environment was proved to be one in which moisture fluctuations were very small, generally because of a favourable soil structure, associated with adequate protection against drying winds

afforded by depressed topography, suitable windbreaks and effective overhead shade. On the chemical side, the especial importance of phosphate supply in cacao nutrition was discovered ; most of the clay types of soil were found to be deficient in available phosphate, though some of the sandy types were found also to be deficient in available potash, shortage of this nutrient often being manifest by a characteristic marginal leaf-scorch symptom. In almost every case, the soils were proved to contain adequate supplies of nitrogen, an unexpected result and one contrary to the general impression among planters.

The identification of nutrient deficiencies naturally led to field manurial experiments in Trinidad. Some very striking results were obtained. Thus, a case of phosphate-deficient marly-clay soil was revealed where small dressings of superphosphate manure gave *over 100 per cent. increase* in yield during the year following the application. On the other hand, phosphate manures were found not to benefit phosphate-deficient soil containing gypsum, which partly explains the low productivity of gypseous clay soils (which are rather widespread in Trinidad.)

Application of the principles and findings outlined above, as established by the ecological researches in Trinidad, to the somewhat different conditions that obtain in Tobago and Grenada has helped to confirm their fundamental significance, and has proved helpful to the cacao planters. The most searching test, however, was furnished by an attempt to apply them to conditions obtaining in the Gold Coast Colony. Through the co-operation of Mr. M. Greenwood, Chemist of the Gold Coast Department of Agriculture, a series of 210 soil samples, representing 21 profiles at selected sites in the cacao belt were collected in 1936 and 1937 and forwarded to the College for laboratory analysis and assessment. The results, considered along with yield data and general local information regarding the features of the environment of the cacao trees surrounding the different sites, provided useful comparison with conditions in the West Indies. The conclusions drawn from them are thought to be directly applicable to cacao growing in the Gold Coast ; they are to be considered and utilised in future research schemes in that Colony. Similar comparative investigations have recently been conducted at the College with reference to the cacao soils of Nigeria. A recent publication describing cacao investigations in Samoa indicates that the results of the College ecological researches are being duly considered and applied there also ; so they have evidently attracted considerable attention outside Trinidad.

Whereas botanical constitution and environment together cover the factors governing yield, in the case of quality a third set of factors come into play, namely those introduced by the treatment of the crop between harvesting and marketing. A necessary preliminary to a scientific study of preparation is an understanding of the biochemistry of the bean, and accordingly investigations have been commenced, the object of which is to attempt to define quality of cured cacao in terms of chemistry of the living bean.

This is an ambitious project, and a good deal of preliminary work must be performed which is of necessity exploratory in character, and often abortive in result. Thus it has been found in the past that similar researches on factors determining quality in commodities such as tea and coffee have yielded very little data of immediate value, and much of the information gained appears at first to be merely empirical. In the case of the biochemistry of cacao, the main essential is to investigate as many as possible of the chemical constituents of the bean. Available literature shows that the published results are seldom in agreement, and the development of more accurate analytical methods would therefore appear to be our first concern.

The Present Position and Outlook for the Future.

The full scope for further research can only be made clear by a rather more detailed discussion of the present position in the industry. Passing reference may be made to another crop, on which a far larger number of workers has been engaged, and for a longer time, as proof of the profitability of research. Long-range research is in its infancy as applied to tropical tree crops in general, and even in the case of rubber, the history of intensive investigation covers little more than 20 years. Nevertheless, comparison with the rubber industry is interesting, because although the products are very different the problems of rubber-growing and of cacao-growing are in many respects similar.

Selection, propagation and ecological investigations with rubber have already shown that yields can be at least *doubled* by the application of their results, with a corresponding reduction in costs of production ; and well-informed opinion is confident that further advances will be made. The verdict of the practical grower is reflected in the replanting programmes of the plantation companies, and can be read in their annual reports.

There is no doubt at all that equally striking results can be obtained in the cacao industry. Research can, indeed, do more in the latter case, because cacao is genetically much more complex and for that very reason provides much wider scope for exploitation.

The potentialities will be discussed, for convenience, under three headings, though none of them can be studied properly without reference to the others. These are: (1) The position with regard to botanical varieties ; (2) The influence of environment and agricultural treatment on the crop ; (3) The need for further biochemical studies of the bean.

1. Botanical Variety in Cacao.

The subject of botanical varieties in cacao is important, complicated, and still imperfectly understood. The basic fact to be remembered is

that "cacao" in the wide sense, is not one botanical species, but several. There are at least four main groups of cacao varieties occupying northern South America, and for practical purposes we may regard these groups as distinct species, leaving their exact botanical status to be determined later. There is a fifth type in the same region that is perhaps to be regarded as distinct, and there is certainly a sixth in Central America, where yet more may be found on exploration. Of all these, only two enter to any appreciable extent into the world's markets. *Theobroma leiocarpa* Bern. in a fairly pure condition supplies most of the "ordinary" cacaos, and complex mixtures of hybrids between *Th. leiocarpa* and *Th. Cacao* L. provide a large proportion of the "fine" cacaos.

The work so far done has consisted of selection of efficient trees within the commercial populations, and this was the necessary first step, because each varies within itself, the hybrid population represented by Trinidad cacao more widely than any other. Selection in the case of the Cacao Research Scheme was concerned with this hybrid population and gave striking results. In West Africa it has been carried out on what appears to be a pure species, in which the tree-to-tree variation is initially less, but if the results are on that account less striking, they are none the less clearly beneficial. In neither case is it to be supposed that the limit of possible improvement has been reached, but with the principles established, selection now becomes a matter more for local than for centralized or long-range research.

For long-range research the next task is to exploit the hitherto almost unstudied species and varieties, and by combining them with the best elements in the commercial populations to build up new types of still greater efficiency. The possibilities in this direction can be illustrated by two examples, one concerning quality and the other disease-resistance.

The well-known association of low yield with high quality in certain criollo cacaos has tended to create an impression that high quality and high yield are necessarily antagonistic. Genetical survey has clearly shown that for Trinidad cacao this is not true, or at least not to any marked extent. Trinidad cacao is a blend of two species, of which one contributes quality and the other hardiness; individual trees combine the two in varying proportions, and high-yielding trees have been found at all levels of quality short of the very highest.

So far as the highest quality is concerned, the virtual supersession of the pure criollo cacaos in cultivation by hybrids of a lower quality creates a problem very disturbing to some sections of the manufacturing industry. The problem is essentially a botanical one, and the solution lies in discovering, or if necessary building up, new varieties combining the criollo characters with a profitable yield under economic conditions of production. The Cacao Research Scheme has started on this problem so far as its facilities permit, by selecting and propagating for further study a number of the very few pure or nearly pure criollo trees which occur scattered about in the cacao fields of Trinidad and Tobago. The progeny have been planted, in co-operation with the Trinidad Department of Agriculture, on estates where they can be kept under observation, and some of them are already coming into bearing. Extension of work along this particular line depends upon facilities for introductions from the mainland, which have so far been very limited.

Other sections of the industry have other requirements, and therefore our study of quality extends downwards from the highest grades to the present average, always in conjunction with studies of yield. The selections already made cover a wide range and include various botanical types, in the hope of suiting a similarly wide range of agricultural conditions, as well as of manufacturers' requirements. It is important to notice that such a range of selections was only possible because Trinidad cacao already contains more than one species. By bringing in more species, fresh characters are likely to be found which can be introduced into the population with profit.

The second example is the problem provided by Witches' Broom disease, seriously menacing the Trinidad cacao industry and a potential menace everywhere. Dr. Pound, Cacao Agronomist to the Trinidad Department of Agriculture, has recently found evidence of a considerable degree of resistance among the tree population of the upper Amazon. There is every likelihood that such resistance, once found, can be transferred to any other type of cacao if necessary, and no better illustration could be desired of the economic importance of studying the whole of a crop and not merely sections of it.

Witches' Broom is by no means the only disease reducing yield in present-day commercial cacaos; a high degree of resistance to the *Phytophthora* diseases, "black pod" and "canker", would be of tremendous benefit over a much wider area, and what is true of diseases is equally true of other adverse factors. An investigation is already being made into the possible existence of inherent immunity from the attacks of the cacao thrips, a minute leaf-sucking insect, which is a much more important pest of cacao trees in West Africa than in Trinidad. The perpetual struggle is to improve the adjustment between the cacao tree and its environment, and one method is to adjust the constitution of the tree. For this purpose long-range research into all the varieties of the crop is essential.

2. Environment and Agricultural Treatment.

In seeking improved adjustment between the cacao tree and its surroundings, neither can be considered more important than the other, and

despite more than five years of active ecological and soil investigations there are still many problems awaiting solution, which cannot be solved by changes of botanical type. Changes of type, indeed, are likely to stimulate ecological researches rather than to render them unnecessary, because the greater the potentialities of the tree the better will it pay for good agricultural treatment. All experience indicates that many of the causes of low productivity in cacao are to be found in the environment in which it is grown, including in that term both soil and atmospheric conditions, and a precise knowledge of those conditions and their effects is the first step towards such modification of them as may be possible.

The researches already made by the chemical section of the Cacao Research Scheme have largely concerned methodology, as befits their long-range nature. As a result a systematic procedure has been elaborated for periodic measurement of the environment, which may be relied upon to reveal the limiting factors wherever it may be applied.

Foremost among the problems to which it may be applied in Trinidad is the general phenomenon of fruit-shrivelling, which is of much more than local importance. The shrivelling and blackening of a large proportion of young fruits long before reaching maturity is a striking feature of the cacao crop, and seems to be analogous to the shedding of immature fruit well known in other species. It often appears to be a main direct cause of loss of crop. Much attention is now being paid to the problem by cacao research officers, and there is little doubt that environment plays a very important part in the process. By periodic physical and chemical measurement of soil and atmospheric factors within contrasted plots, having different reputations in this respect, we hope to identify the main cause or causes, and recognition would be the first step to amelioration. Considerable progress has been made in this direction in recent months.

An environmental factor brought into prominence by the discovery of self-incompatibility is the presence and action of pollinating agents, which are themselves presumably dependent on ecological conditions. It is surprising that at this date we still do not know with certainty the agent that carries pollen from tree to tree, still less what connection there may be in commercial plantations between pollination and yield. Serious investigation of these problems has been begun during the last 12 months.

In all studies of environmental influence, including for example manurial trials, a most important factor is the uniformity of the trees used for experiment. Recent advances in the technique of vegetative propagation have made possible much more precise investigations than were ever possible before. This is a very valuable interim result, though one easily overlooked because its benefits are indirect. It provides an excellent illustration of the rôle of long-range investigations in expediting local research.

3. Biochemistry of the Bean.

Reference has been made to the start already made with the object of attempting to define quality in terms of chemistry. In order to acquire an insight into the biochemistry of the bean, it is necessary first to follow its developmental history, which can only be done in a cacao-growing country. The developmental history should bring out more clearly the differences between the various kinds of cacao than a mere comparison of the mature seeds. The results obtained are likely to have a bearing on the important problem of pod shrivelling and might possibly cast light also on pod diseases, linking up with the physiological investigation of the cacao tree.

Here again the ability to propagate quantities of genetically uniform cacao is a powerful weapon for research, and the studies of botanical variety can bring to the chemist a wider range of material for his comparisons, out of which quite unexpected results may come.

Conclusion and Summary.

One last point needs to be made about long-range research in cacao production, and that concerns its finances. As at present organized, the cacao-growing industry is not in a position to finance or control directly investigations which by their nature can only produce their full economic results after a lapse of some years. The bulk of Empire cacao is peasant produced, and the proportion grown on plantations is almost entirely the produce of small estates. Long-range research is essentially a long-term investment, and without action by Governments and public-spirited manufacturers there could be no such investigations in cacao. The completion of the work described in the first section of these notes, and the taking up of that discussed in the second, are therefore entirely dependent on the continuation of the support which has been forthcoming since 1930, and the rate of progress must depend on whatever increased support can be obtained in the future.

Lest the stressing (in fairness to supporters) of the long-range aspect should obscure the true position, the substantial interim results already obtained are here re-summarised:—Selected material of a very high standard of yielding power and of various grades of quality is now available to the planter ; a practicable process of vegetative propagation is ready for application ; and plantings have been made under estate conditions which are beginning to bear and to provide figures of actual yields of selected material. Information about self-incompatibility in cacao, more precise knowledge of what constitutes a good environment for the tree, and the identification of nutrient deficiencies leading to means for their cure are applicable to established cacao as well as to new plantings or in re-habilitation of old fields. On the longer-term side, vegetative propagation has made possible greater precision in future field experiments, methods of estimation in biochemical studies have been improved, and horticultural experiments have been planted to yield information continuously for many years to come.

PROGRESS IN SUGAR-CANE AGRICULTURE IN ANTIGUA DURING THE PERIOD 1933-40.

By P. E. Turner.
Adviser in Sugar-Cane Experiments to the Commissioner of Agriculture.

Introduction.

In 1933 a scheme of field experiments was inaugurated in Antigua under the auspices of the newly formed Sugar-Cane Investigation Committee. The main aim of the scheme is to make thorough and systematic enquiry into the fundamental practices of agriculture in standard use in the sugar areas of the island. The scheme has been in operation for seven years. In this paper the main achievements of the scheme during this period are briefly outlined.

A critical review by the author of the agricultural practices in use in Antigua in 1933 has been published elsewhere (1). The results of the earlier experiments have been recorded in *Tropical Agriculture* (2) and of the later experiments in the *Annual Reports on the Agricultural Department of Antigua* (3). The soil types of the island have been described, classified and mapped on a satisfactory basis by C. F. Charter (4).

A gyrotiller was imported into Antigua in 1931 and tractors have since been purchased. In 1931 H. E. Box (5) began his researches on the control of moth borer. His work is being continued by the Antigua Sugar Factory. The introduction of mechanical methods of cultivation and the investigations of Box and his collaborators have assisted greatly in the progress made by the industry. Reference will later be made to new varieties of cane imported from Barbados.

The soils mentioned in this paper are classified for cultural purposes into two groups, namely, soils with impermeable clay subsoils and soils with permeable marl subsoils. To the former belong the Gunthorpe, Lindsey and Tomlinson series of the Gunthorpe Suite, the Otto and Briggin series of the Otto suite and the York and Bendal series of the Montero Suite. To the latter belong the Fitches, Wetherell and Hodge series of the Fitches Suite (4).

Cultural Methods.

Preparatory Cultivation and Drainage.

Soils with clay subsoils.

In 1933 there was in general no systematic arrangement of drains in these soils. Main and outlet drains were few in number and functioned inadequately. Field drains were unevenly spaced and irregular in direction. Ploughing was very frequently carried out late in the season and was performed across the field drains which were destroyed during the operation. The earth from the newly made drains was placed on the edges of the beds causing them to become hollow in form. Consequently drainage even on the calcareous soils of this group was very poor and they retained the tilth given to them by tillage only for a short time. The cane suffered severely from excessive moisture during wet weather and from drought during dry weather. Root diseases were rife and response of the cane to rain was slow and limited.

Parallel field drains, evenly spaced, with cambered beds between, were introduced during the early years of the experimental scheme on representative areas of these soils. The drains at first were placed 25 feet apart but it was found that in general the distance could satisfactorily be increased to 30 feet. This system of drainage with cambered beds has proved its value not only in average years but also in very wet and very dry years. It has led among other things to remarkable and sustained improvement in tilth of the soils of this group, to an equally remarkable reduction in the prevalence of root diseases and to better ratooning. Up to the present over 1,000 acres have been drained and cambered in this manner and the area is likely to increase greatly in the future. On this area adequate attention has also been paid to main and outlet drains.

On the cambered areas ploughing is performed by the gyrotiller or tractors along the beds. Consequently the drains between the beds are never destroyed. Once they are laid down it is necessary only to keep them open and not to remake them. The purchase of additional tractors has enabled ploughing to take place earlier and under much more suitable conditions than in previous years. Ploughing to a depth of 12 to 14 inches is recommended. Cambering at present is done by hand but in due course mechanical means are likely to be employed. The optimum depth of the drains between cambered beds is still under study on the various soil types. At present they are sunk about six inches below the depth of ploughing.

Soils with marl subsoils.

A systematic arrangement of field drains with cambered beds is not necessary on these soils. It is doubtful whether ploughing (as distinct from furrowing) is needed except to help in the eradication of weeds and experiments are under way to determine whether ploughing pays.

Furrowing (or Banking).

Soils with clay subsoils.

Furrowing (or banking) as well as ploughing was at one time carried out across the beds. Since the introduction of parallel field drains with cambered beds it has been shown that satisfactory results can be obtained by furrowing along the beds by tractor-drawn or cattle-drawn implements.

Furrowing along the beds is now practised on almost the entire cambered area. Six furrows are made in each 30 foot bed but closer furrowing may be found more advantageous. The more expensive method of furrowing by hand across the bed is still in use, however, on certain areas.

Soils with marl subsoils.

On these soils no problems have arisen with regard to the direction of furrowing as closely-spaced field drains are not required.

On both groups of soil it was usual in Antigua to make the furrows nine inches deep with elaborately prepared banks. It has been shown that a depth of five inches is ample, and that highly finished banks are unnecessary.

Breaking of Banks.

It was formerly not customary to break the banks, *i.e.* return the earth to the furrows. On the contrary, effort was made to retain the banks as far as possible.

Soils with clay subsoils.

It has been shown essential to break the banks to ensure maximum yield of cane, especially if the furrows are made along the beds, and this operation has been largely adopted on the cambered areas. It is best performed in stages six to ten weeks after planting, *i.e.* before the soil has dried out.

Soils with marl subsoils.

Breaking the banks is not of such importance but among other things it enables the cane more easily to be cut flush with the soil and it facilitates carting during the crop season.

Tillage of Ratoons.

On the areas of both soil groups in which experiments have so far been laid down tillage of ratoons has not been found to give rise to gain in yield of cane provided that preparatory cultivation has been satisfactorily carried out. Consequently tillage of ratoons is on the decrease.

Weeding of Plants and Ratoons.

No experiments have been laid down to measure the value of weeding. There is evidence available, however, which suggests that neglect of clean weeding can lead to losses in yield larger than five tons of cane to the acre.

Mulching.

Mulching with trash has been practised sporadically for many years. It has now been established that if this operation is to give rise to paying gains in yield it is essential for the mulch to be applied to young plant cane before the advent of the dry season, *i.e.* when the soil is still moist. Further it has been shown that unless the young plant has been satisfactorily manured, the moisture conserved by the mulch may have only limited beneficial effect.

A number of estates are now endeavouring to mulch with trash at the optimum time as a routine operation. Problems as to the most efficient method of collecting trash from the field and stacking it for later use as a mulch await solution.

Varieties.

A large number of varieties, mainly from Barbados, have received exhaustive and critical trial on the various soil types. In consequence the varietal situation in the island has undergone great change (Table I). In 1934 the most popular varieties were B.H. 10 (12), B. 147 and Ba. 11569. The variety B. 147 has now almost disappeared from cultivation and B.H. 10 (12) is rapidly disappearing. Ba. 11569 has become the standard variety on the areas with clay subsoil and the new variety B. 2935 on the areas with marl subsoil. Another variety, B. 3439, is showing excellent promise in experiments and is likely to become a standard cane in the near future.

Table I.

Proportional distribution of sugar-cane varieties harvested in Antigua (1934-40).

Crop year.	Percentage of total area harvested.				
	Ba. 11569.	B. 2935.	B.H. 10 (12).	B. 147.	Miscellaneous.
1934	14.0	Nil	37.2	26.0	22.8
1935	21.5	Nil	43.6	9.9	25.0
1936	23.0	0.8	35.7	8.6	31.9
1937	33.0	9.1	24.6	11.9	21.4
1938	36.2	13.8	20.7	13.3	16.0
1939	38.3	24.8	17.6	1.9	17.4
1940	48.1	26.7	10.4	0.8	14.0

The adjustment of the varietal situation to meet soil conditions has helped greatly in minimising the damage resulting from root diseases.

Germination.

In Antigua germination was at one time uncertain and extensive and continued supplying was frequently necessary. Charter (6) has shown that germination is very greatly improved by soaking the cane setts for 48 hours in a saturated solution of lime water. Charter (6) has further shown on one soil type that setts taken from cane which had been generously dressed with water-soluble inorganic nitrogen and phosphate, or with pen manure, give more satisfactory germination than setts from unmanured cane or cane dressed with nitrogen or phosphate alone, and Warneford (6) has assembled evidence which confirms this discovery in general. If these findings are observed no difficulty is experienced in obtaining good germination provided that preparatory cultivation is not unduly delayed, that a suitable variety is planted at the recommended time and that on areas with clay subsoil a system of parallel field drains with cambered beds is in operation.

Time of Planting.

In 1932 on many estates only one-half to two-thirds of the ploughed areas were planted before the end of the year. On some estates the proportion might fall as low as one-third to one-half.

November has been shown on the average to be by far the most satisfactory month for planting (with rare exceptions) whether the year is wet, normal or dry. Approximately 90 per cent. of the area harvested in 1940 was planted before the end of the year.

Distance of Planting.

Soils with clay subsoil.

Critical information is not yet available as to the optimum number of furrows to a cambered bed or the optimum spacing of plants in the furrow. Double planting has been shown on one soil type not to give appreciably better results than single planting.

Soils with marl subsoil.

The optimum spacing would appear to be three to four feet in furrows five feet apart but additional experiments are needed before definite recommendations are possible.

Manures.

In 1932 organic manures alone, *i.e.* pen manure, village manure and sheep manure, were applied to plant cane in Antigua. Dressings to the acre as heavy as 40 tons of pen manure or 10 tons of sheep manure were added to part of the area while little or no manure might be given to the remainder. Sulphate of ammonia was applied to ratoons but the use of inorganic manures was in general profoundly distrusted.

It has been shown that it does not pay to keep additional stock solely to augment the supply of pen manure, that pen manure does not lead to gain in yield of plant cane unless it has been allowed ample time to decompose, that the optimum dressing of pen manure of good quality in the absence of inorganic manures lies in the region of 12 to 15 tons to the acre and that pen manure gives more satisfactory gains in yield in wet than in dry years.

On the calcareous soils of the island it has been established that sulphate of ammonia, if used alone, cannot be relied upon to give paying gains in yield, but that if it is applied with water-soluble phosphate paying response of plant and ratoon cane results. On the non-calcareous soils also the addition of water-soluble phosphate has been found advisable with nitrogen.

It has been shown that in the presence of sulphate of ammonia and superphosphate the gain from pen manure of good quality may be reduced to zero and that water-soluble inorganic nitrogen and phosphate can give as large or larger gains than pen manure on soils which have never been dressed with organic manure. It would appear that the value of pen manure depends primarily on the rapidly available nitrogen and phosphate which it contains. There is every reason to believe that organic manures are not essential for satisfactory growth of sugar cane in Antigua and that the industry could be successfully continued and expanded without their use.

It is recommended that the supply of pen manure should be distributed as evenly as conditions permit over the area to be replanted, and that a dressing to the acre of 2 cwts. sulphate of ammonia and 2 cwts. superphosphate, or the equivalent (*e.g.* in the form of ammonium phosphate), should be applied to plant cane and to each ratoon on all soil types. The use on plant-cane areas of filter-press mud (a waste product of the sugar factories which contains quickly available nitrogen and phosphate), rather than the purchase of sheep manure, at the rate of five tons to the acre is advised as an alternative to pen manure. These recommendations have been put fully into effect on a number of estates.

In consequence of the very high concentration of readily available calcium in the soils of Antigua it has been found essential for the dressing of water-soluble inorganic nitrogen and phosphate to be given to plant cane within a month after planting under moisture conditions which favour its rapid absorption by the young plant. Later application, even under wet conditions, cannot be relied upon to have beneficial effect. Experiments are under way to determine whether the dressing should be applied as early as the time of planting to ensure maximum benefit. The dressing to ratoons should be given as soon as possible after reaping.

The recommendation as to the size of the dressing (2 cwts. sulphate of ammonia and 2 cwts. superphosphate to the acre, or the equivalent) to plant and to ratoon cane is provisional. It has been shown to give very paying gains in yield in wet and average years, and even to paying gains in an extremely dry year, but there are indications that a larger ratio of nitrogen to phosphate might prove still more satisfactory. The optimum ratio of nitrogen to phosphate and the optimum size of total dressing may also be found to vary with soil type, with variety and with crop (plant or ratoon cane).

The effects of a second and later dressing of nitrogen to plant cane are still under investigation. Later additional phosphate has not been found to pay. Borax has been found to give rise to a small gain in yield of plant cane on one soil type, but negative results have so far been obtained from experiments with other minor elements, *e.g.* manganese, magnesium, copper, zinc and ferrous iron. In general the soils have been found to contain ample stores of readily available potash.

It will be seen from Table II that confidence in inorganic manures is steadily increasing and that they are being more advantageously used.

TABLE II.

Inorganic manures imported into Antigua (1935-39).

Inorganic manure.	1935.	1936.	1937.	1938.	1939.
Water-soluble phosphate as P_2O_5 (tons) †...	*	25.2	36.9	41.1	59.6
Nitrogen as N (tons)‡	*	67.9	88.8	79.4	93.6
Potash as K_2O (tons) ...	*	5.8	2.8	2.8	Nil
Value of imported phosphate, nitrogen and potash ...	£2,069	£2,748	£3,962§	£4,409	£4,787

Before 1933 no phosphate was imported into the island. 122 tons of superphosphate were imported in 1936, 137 tons of superphosphate and 75.5 tons of ammonium phosphate in 1937, 45 tons of superphosphate and 185 tons of ammonium phosphate in 1938, no superphosphate and 331 tons of ammonium phosphate in 1939. The transition from superphosphate to ammonium phosphate reflects progress in the experimental work. The earlier experiments were made with sulphate of ammonia and superphosphate while it was later shown that ammonium phosphate gives equally satisfactory results.

The amount of nitrogen imported has increased from 67.9 to 93.6 tons, *i.e.* by 38 per cent. in the four years 1936 to 1939. Before phosphate was extensively applied much of the nitrogen was probably used with little benefit.

The total value of the inorganic manures imported has increased during 1936-39 from £2,069 to £4,787, *i.e.* by 131 per cent.

Schedule of Estate Operations for Plant-Cane Areas.

In many sugar-producing areas there is a considerable degree of latitude in the time at which the various items in the sequence of agricultural operations on plant-cane areas can satisfactorily and efficiently be carried out. In Antigua, however, as the wet season may be very short and the dry season very long (2) it is necessary to conform as closely as possible to a time table if maximum use is to be made of the rain and minimum harm is to result from the drought. The time table is summarised below.

1. Ploughing, cambering and draining should be completed before heavy and continued rain sets in. In general this requirement can be fulfilled without difficulty if adequate mechanical means are available. The soils of the sugar areas as a whole cannot be given a good tilth if intensively worked in wet condition. Poor tilth leads to poor germination. Poor germination can totally upset the time table of operations which follow planting.

2. Weeds should be eradicated as far as possible before furrowing. Ploughing in dry weather, and cambering on areas with clay subsoils, assist greatly to this end. It should from then onwards be possible inexpensively to keep the soil free of weeds.

3. Furrowing (and any remaining operations preparatory to planting) should be finished by the end of October in order that the full resources of the estates may be available for planting.

4. Planting should be begun early in November and completed by the end of November. Conditions for good germination as a rule are at their optimum during this month. If planting takes place earlier than November there is considerable chance of the young cane being too advanced in growth to withstand a long dry season. Later planting involves the risk of the advent of the dry season before the inorganic manures can be absorbed by the young cane. Further it entails the risk of poor germination in circumstances such that months may elapse before there is adequate rain for satisfactory supplying.

5. Inorganic manures should be applied within one month after planting for reasons which have been given.

6. Banks should be broken and the mulch of trash applied at the latest by the middle of January, *i.e.* the time at which the dry season on the average begins.

It is worthy of note that the complete schedule of operations on plant-cane areas has been put into practice by some estates, without difficulty and with very definite advantage, over a period which has included wet, average and dry years.

Early Benefits from the Experimental Scheme.

The annual rainfall of Antigua and the distribution of the rainfall are very variable (3). Consequently yield to the acre varies greatly from year to year. Comparative data to be of value, except in special cases, must be based on average returns for a number of years. The data recorded in Table III are for the seven-year periods before and after the inauguration of the experimental scheme. The average yield for the latter period is larger than the former by 3.71 tons of cane to the acre.

* Data for 1935 and earlier years not available.

† Water-soluble P_2O_5 calculated as 17 per cent. in superphosphate and according to analysis in ammonium phosphate.

‡ Nitrogen calculated as 20 per cent. in sulphate of ammonia and according to analysis in ammonium phosphate.

§ Includes the value of 5 tons of a complete inorganic manure of unrecorded composition.

TABLE III.

Average yields of cane to the acre for all Estates supplying the Antigua Sugar Factory.

Period.	Average yield of cane (tons per acre).
1925-32	14.70
1933-40	18.41
Difference	3.71

As the findings of the experimental scheme are put more fully into operation, and as fresh information becomes available, the difference is likely greatly to increase. It is worthy of note that both 1930 and 1939 were exceptionally dry years. The average yield of cane to the acre in 1931 was 5.66 tons. In 1940 it was 15.82 tons.

The full benefit of the findings can be obtained only when the schedule of operations recorded in the previous section is put into effect as a whole. Many estates have so far adopted it only in part. For example, very large areas with clay subsoils remain to be systematically drained and cambered and are still ploughed unduly late. Until these conditions are remedied maximum gain cannot be derived from the discoveries made with regard to such fundamental factors as varieties, time of planting and inorganic manures.

On areas in which the complete schedule of operations has been adopted a greater average yield of cane is not the only consequence of the experimental scheme. The cost of establishing a field of plant cane is reduced. Longer ratooning is practicable, and this not only increases the number of crops which can advantageously be taken off between the comparatively costly operations involved in replanting but also enlarges the proportion of the arable area which is being cropped at any one time. Longer ratooning lessens somewhat the average yield of cane but it greatly reduces the average cost of a ton of cane as the expenditure on ratoons is relatively small.

It is probable that much of the sugar-cane area which in the past has been abandoned in Antigua could inexpensively and profitably be brought back into cultivation as a result of the findings of the experimental scheme.

Acknowledgments.

The idea of the investigational schemes on sugar-cane in the Leeward Islands was conceived by the late Mr. G. Moody Stuart, C.B.E. The scheme was launched by Mr. G. A. Jones, C.M.G., then Commissioner of Agriculture.

The scheme is financed by the cane growers, who contribute one cent for each ton of cane delivered to the sugar factories, and by the factories which provide an equal sum.

The author wishes to place on record his indebtedness to the sugar estates for their very helpful co-operation in the work and to Mr. F. H. S. Warneford and Mr. C. F. Charter for the invaluable assistance which they have given.

References.

(1) Turner, P. E. (1934).—A Critical Review of Agricultural Practices on Sugar Estates in Antigua with Special Reference to a Scheme of Field Experiments. Published by *Sugar-cane Investigation Committee of Antigua.*

(2) Turner, P. E., Warneford, F. H. S. and Charter, C. F. (1936 and 1937).—Recent Investigations on Sugar cane and Sugar-cane Soils in Antigua. *Tropical Agriculture*, XIII, 1, p. 19; 2, p. 38; XIV, 5, p. 150; 6, p. 179.

(3) Warneford, F. H. S. (1935-39).—Reports on the Agricultural Department of Antigua. Issued by *Commissioner of Agriculture, Imperial College of Tropical Agriculture.*

(4) Charter, C. F. (1937).—Soil Survey (Reconnaissance) of Antigua and Barbuda, Leeward Islands. Published by *Government of Antigua.*

(5) Box, H. E. (1938). — Some Aspects of the Campaign against the Moth Borer (*Diatraea saccharalis* Fabr.) in Antigua and St. Kitts, 1931-38. *Proceedings of the Sixth Congress of the International Society of Sugar Cane Technologists, Louisiana.*

(6) Unpublished communications.

LASTING EFFECTS OF MOLASSES AS A FERTILISER.

Molasses as a fertilizer has a particular value on potash-poor red volcanic soils, because of the richness of the by-product in this plant nutrient. But it has also been found that molasses applied to such soils, in dry areas, brings with it another benefit, particularly when weak-rooting canes such as Q.813 are grown. It would appear that the molasses destroys the influence of root parasites which often exist under such conditions, and the weak-rooting canes give a normal ratoon yield. In one test on such a soil, a ratoon field of Q.813 treated with ten tons of molasses to the acre showed a gain of 6½ tons of cane. After this crop had been harvested, the farmer ploughed out the area, and broadcast Poona Pea as a cover crop, in October. Particular notice was taken of the growth of the pea crop to see whether the molasses treatment showed any "carry-over" effect. In every instance it was found that the growth of the legume on the plots which had received 10 tons of molasses a year earlier was far in advance of that on the "no treatment" plots. Evidently, the pea crop was benefited by the excess of potash that was not used by the previous ratoon cane crop. Thus, in calculating the benefit of such treatment on this kind of soil, the farmer may consider not only immediate results, but may allow also for more permanent effects.—(*Facts about Sugar*, Vol. 35, No. 1, p. 32, 1940.)

CULTIVATION OF BANANAS UNDER SHADE FOR THE CONTROL OF LEAF SPOT DISEASE.

By C. A. Thorold, M.A., A.I.C.T.A.,
Plant Pathologist, Department of Agriculture, Trinidad and Tobago.

Introduction.

The present position and the past history of the Cercospora Leaf Spot Disease (*Cercospora musae* Zimm.) of bananas in Trinidad have been summarized by Wardlaw (6).

The disease has spread rapidly since 1933, when it became conspicuous in one small plantation. However, the production of bananas for export has only been seriously affected in the last few years when the *Cercospora* disease became generally distributed throughout the Colony in its present epidemic form. The situation is unfortunate, because as the figures below appear to indicate, an increased interest in banana growing since 1934 has been overtaken by the development of Leaf Spot Disease, with a reduction of export bunches after 1937.

Year.	Number of Stems Exported.
1934	33,701
1935	66,369
1936	159,085
1937	170,614
1938	131,363
1939	66,497
1940 (first six months)	21,351

Cercospora infection causes a serious loss of leaf area, which results in a reduction of both size and number of 'hands.' Another unfortunate feature of *Cercospora* disease is the premature ripening of the bunches with a discoloration of the fruit pulp.

The Control of Leaf Spot Disease.

From the aspect of banana production for export the main object must be to reduce the intensity of *Cercospora* infection to the point where premature ripening and pulp discoloration are no longer adverse characteristics of the fruit.

The disease was first noticed on the Giant Governor, and later on the Dwarf Cavendish variety. It was not long before Gros Michel was also affected, and it is the only important export variety at the present time. Certain *Musa* species are resistant (2), and so is the Imperial College Hybrid, I.C.2 (derived from *M. acuminata* as male parent and Gros Michel as female parent). Unfortunately, I.C.2 has certain undesirable characteristics (7), which militate against its adoption for export as a resistant substitute for replacing the susceptible Gros Michel. It is possible that further breeding work may produce a suitable variety in which resistance to Leaf Spot disease is combined with the desirable characteristics of the Gros Michel, but at the moment other methods for combating the *Cercospora* have to be found.

Spraying experiments carried out in Jamaica in 1937, established the efficacy of fungicide sprays and dusts for controlling Leaf Spot Disease (4). However, it has been emphasized that attention must also be given to good cultural practices (1). Ward (5) has summarized the factors, both environmental and those involving the technique of fungicide application, which affect the control of the disease.

On account of the small and scattered plantings of bananas in Trinidad, on land frequently presenting difficulties for the ingress of equipment and machinery, it will probably be uneconomic to attempt the control of Leaf Spot disease by means of protective fungicides in Trinidad.

The Position of Bananas in Trinidad's Agriculture.

Bananas directly contribute only a small amount of the agricultural revenue of Trinidad. However, local sales must be considerable, whilst in the rôle of providing ground shade in the cocoa plantations, bananas have always played an important part in the agriculture of the island. Bananas are commonly planted as shade for young cocoa, but the Gros Michel variety is not generally used. The stools are allowed to remain when the plantations are older, and consequently there are many banana plants occurring amongst the cocoa in all parts of Trinidad,

There are practically no large valleys with level land available for banana cultivation, but there are suitable soils for bananas within the large area under cocoa, which in 1936 was estimated to be 205,000 acres (8).

In 1934, the production of bananas for export received encouragement through the institution of the Banana Board, which contracted with the Canadian Banana Company for the sale of all marketable Gros Michel bunches at fixed prices. Consequently there has been an increase in the banana acreage since 1934, partly by clearing land of cocoa and Immortel trees. The pure stands of bananas in the open later succumbed to *Cercospora*, it then became evident that the only relatively healthy bananas were those receiving some shade.

The Control of Leaf Spot Disease by Shade.

Profiting by this observation, Mr. J. E. J. Beausoleil, Banana Officer in the Agricultural Department, began several experiments in which bananas in the open were compared with adjacent ones, interplanted in the cocoa, with Immortel (*Erythrina glauca* and *E. micropteryx*) trees present also. Observations so far leave no doubt that shade effectively checks the Leaf Spot disease, so that a normal healthy bunch can be matured without the stunting and premature ripening which result from severe *Cercospora* attack.

It is not possible yet to state precisely in what way the shade acts in controlling the disease. It would seem, however, that the desideratum is a reduction in hours of direct sunlight incident on the bananas. It appears that the topographical features of the plantation are important. Where bananas are planted on a steep slope the reduction in hours of full sunlight caused thereby is influential in reducing the amount of Leaf Spot disease. This and other points in connection with the shading of bananas need further experimental confirmation before it is possible to prescribe exactly the nature and amount of shade required. At the moment, it is necessary to steer a middle course between lack of shade and too dense an overhead canopy, which latter adversely affects the rate of growth and production of fruit.

The expression 'Shaded Fruit' is sometimes used in a derogatory sense to denote the abnormal fruit produced under conditions of overcrowding, involving either over-population, or too many stems from each rhizome. Such mutual shading is not advocated now. It is intended that the bananas shall be adequately spaced and pruned, so that they may have ample room for proper development, but at the same time receive overhead shade.

Recommendations.

There are now many fields of cocoa which on account of disease and low prices are in an abandoned, or seriously neglected condition. Tall cocoa trees and the Immortels shading them can be turned to greater advantage by providing shade for the cultivation of Gros Michel bananas. It is recommended that suckers should be interplanted in the cocoa in such a way that the banana may benefit by the overhead shade. Where there is a good stand of Immortels present, these trees will be the best means of shading the bananas as there should be no low branches to impede development. If successful use is to be made of the combined shade from the cocoa and Immortel trees in providing an overhead canopy for the bananas, then attention must be given to careful pruning of the cocoa.

Practical advice on banana production including planting, pruning and reaping, has been given by Harragin (3) for the special circumstances of interplanting in cocoa.

Scarring of Fruit.

The market requires fruit of high quality; the banana bunch is very susceptible to scarring from the time when the flower spike emerges until the bunch is received for sale. Therefore it is most important to ensure that the ultimate appearance of the bunch is not impaired by interference from the cocoa. It must be anticipated that scarring will be more frequent when bananas are cultivated under cocoa and Immortel shade, as opposed to pure stands of the crop. The small mammals, such as manicou and squirrels, are common vermin of cocoa estates and in their progress through the cultivation they are liable to make scratches and claw-marks on the ripening fruit.

Thrips (*Frankliniella* spp.) produce superficial blemishes on the fruit. A very large proportion of the exported bananas have been slightly damaged by thrips, but only a severe infestation causes the fruit to be rejected. These insects are of common occurrence in Immortel flowers, so that bananas cultivated in cocoa plantations may be expected to suffer more from thrips injury than those grown in the open.

Summary.

1. The spread of Leaf Spot disease of Bananas in Trinidad since 1933 has caused a reduction in the number of bunches available for export.

2. Severe attack by *Cercospora musae* results in premature ripening of the fruit and consequent troubles in transport and marketing.

3. Certain *Musa* species are resistant, so also is the hybrid I.C.2, bred at the Imperial College of Tropical Agriculture. However, this hybrid, is not entirely suitable for export and cannot at the moment replace the Gros Michel variety.

4. Control of Leaf Spot disease by spraying and dusting have been achieved in Jamaica, but in Trinidad the nature of the banana industry renders the application of fungicides uneconomic.

5. It has been observed that the pure stands of bananas in the open suffer greatly from Leaf Spot disease, but where the amount of sunlight is reduced by topographical features or by an overhead canopy of natural shade, the disease incidence is very much less.

6. There are many Gros Michel bananas still flourishing where they were originally planted as ground shade for the cocoa. It is recommended that extended use be made of such interplanting, so that Leaf Spot disease may be circumvented by utilising the cocoa and Immortel trees for providing overhead shade.

7. It is recognised that scarring of fruit will be greater under shade.

References.

1. Barnett, W. L. and Ward, F. S.—Extract from Report on Leaf Spot Disease of Bananas, *Journal of the Jamaica Agricultural Society*, 42, pp. 555 and 557, 1938.
2. Cheesman, E. E. and Wardlaw, C. W.—Specific and Varietal Susceptibility of Bananas to Cercospora Leaf Spot, *Tropical Agriculture*, XIV, pp. 335-336, 1937.
3. Harragin, S. G.—A few Suggestions on Growing Gros Michel Bananas in Cocoa, 47 pages, Yuille's Printerie, Trinidad 1934.
4. Ward, F. S.—Cercospora Leaf Spot of Bananas, *Journal of the Jamaica Agricultural Society*, 42, pp. 23-24, 1938.
5. Ward, F. S.—Factors affecting the Control of Cercospora musae, *Journal of the Jamaica Agricultural Society*, 43, pp. 483-487, 1939.
6. Wardlaw, C. W.—Cercospora Leaf Spot Disease of Bananas, *Nature*, 44, page 11, 1939.
7. Wardlaw, C. W., Leonard, E. R. and Barnell, H. R. —Metabolic and Storage Investigations on the Banana, *Low Temperature Research Station, Imperial College of Tropical Agriculture*, Memoir 11, 1939.
8. An Economic Survey of the Colonial Empire (1936) *Colonial No.* 149, p. 440, *H. M. Stationery Office, London*, 1938.

CONTROL OF PINEAPPLE CATERPILLAR.

By C. A. Thorold, *Plant Pathologist* and A. Pickles, *Entomologist*, (*Department of Agriculture, Trinidad*).

Both cultivated and wild growing pines in Trinidad are attacked by the larva of the Lycaenid butterfly, *Tmolus echion* L. (*Thecla basilides* Geyer). The damage is usually noticed first by the presence of gum on the outside of the fruits. Beneath the gum there is either a shallow depression or more usually a small circular hole made by the larva burrowing in the fruit.

A description of the stages and an account of the biology of this insect has been given by Harris (1), who recorded that the production of gum was apparently a specific reaction to *Tmolus* larvae. Therefore, this characteristic of the injured fruits has been used as the criterion of attack in the observations now to be recorded. Other animals and mechanical damage may cause similar holes in the fruit, but apparently without the exudation of gum.

An experiment has been carried out on Mr. Graham's pineapple plantation near Salibea, as a preliminary trial of methods for preventing the damage to pineapples caused by the larva of *Tmolus*. Harris (*loc. cit.*) describes a preliminary experiment in which a single application of Bordeaux Mixture was employed to control the pest. Although this experiment gave encouraging results, it was considered by us that a substance of more definitely insecticidal value was required. The choice of an insecticide for the purpose, however, is limited by the necessity for a preparation which is non-poisonous to human beings, as the marketing of the crop affords little opportunity for the removal of poisonous spray residues. Two proprietary derris preparations, readily available in the Colony, were therefore selected for trial in these experiments.

Treatments.

Untreated control plants were compared with the following four treatments:—

1. Derrimac applied once every week;
2. Derrimac applied once every fortnight;
3. Derrisol applied once every week;
4. Derrisol applied once every fortnight.

The spray was applied to the fruits only, at a dilution of 1 ounce Derrisol to 3 gallons of water (U.S.A. measure), using a Myers Kwikfill Sprayer.

The Derrimac dust was also applied to the fruits only.

The treatments commenced on 27th March, and the experiment ended on 4th July, when the last ripe fruits were picked.

Plot Arrangement.

The site of the experiment was a rather steep slope facing south-east. The pines had been planted in rows following the contours.

On account of the variation of soil conditions to be expected up and down the slope, a randomized block lay-out was employed. Each of the four insecticide applications and the control (referred to henceforth as the five treatments) was represented once within each row, constituting a block. Fourteen such blocks were demarcated, giving that number of replications of the five treatments. Two plants were taken to constitute a plot for each treatment, a larger number could not be included, on account of irregularity of the rows and the large number of over-developed fruits and non-flowering plants present.

The procedure adopted in laying out the experiment was to begin at the bottom of the slope and to take each row in turn and in it to select for treatment ten plants with inflorescences or very young fruits, unsuitable plants being ignored. Otherwise no selection of plants was made and the treatments were allotted at random. Whenever a row did not contain ten suitable plants, the entire row was discarded for the purposes of the experiment.

Recording of Caterpillar Damage.

The fruits were picked from the experimental plots when ripe and awarded a mark of 1 or 0, according as to whether they were clean or bored by a *Tmolus* larva.

Each plot could score marks as follows:

2 = 1 + 1, both plants with clean fruit;
1 = 1 + 0, one clean and one damaged fruit;
0 = 0 + 0, both plants with damaged fruit.

In a few cases the fruits were accidentally lost before they could be recorded, in these instances the plants were given ½ mark. Otherwise, if the plots containing such plants had been discarded, only 5 instead of 14 blocks would have been available for the comparison of the treatments.

The total marks for the plants receiving each treatment were as follows:—

Table 1.

Treatment	Total Plants.	Plants Undamaged.	Marks.
Control	25	15	16½
Derrimac once a week ...	25	20	21½
Derrimac once a fortnight	26	22	23
Derrisol once a week ...	26	19	20
Derrisol once a fortnight ...	26	16	17½
Totals	128	92	98½

There was in the experiment a total of 140 plants employed and recorded, so that the maximum possible number of marks was 140, if every fruit had been undamaged.

The total score of 98 marks shows that 70 per cent. of the plants in the experiment were recorded as undamaged, whilst 57 per cent. of the control plants were not attacked.

The numbers of damaged fruits differed considerably in the various blocks. The extent of the *Tmolus* infestation also varied at different dates during the course of the experiment as seen from Table 2.

Table 2.

Date of Picking.	Control Plants.		Treated Plants.	
	Number of fruits reaped.	Percentage of fruits damaged.	Number of fruits reaped.	Percentage of fruits damaged.
1st May ...	0	—	1	100
10th May ...	1	0	3	67
16th May ...	1	100	4	25
27th May ...	1	100	3	33
29th May ...	2	0	11	45
6th June ...	2	100	8	38
17th June ...	4	25	14	29
20th June ...	4	75	27	26
28th June ...	9	22	20	5
4th July ...	1	0	10	10

The data obtained have been subjected to statistical analysis, but in no case was the difference between any two treatments significant.

The results can only be taken as indicating that the Derrimac apparently reduced the caterpillar damage, whilst Derrisol was less effective. It is important that there is so little difference between the weekly and the fortnightly applications of dust. It was noticed that the Derrimac persisted remarkably well on the fruits, suggesting that fairly heavy applications at intervals of a fortnight or longer may be sufficient for a useful degree of control.

The stage of development at which the applications of insecticide commence is certainly important in determining the control obtained. Information bearing on this point has been obtained in the course of the experiment. It would seem that the degree of control has increased with the length of time during which the fruits have been treated. The last ones to be picked were those in the early flowering stage at the start of the experiment.

Insecticides were first applied on 27th March.

Recommendations.

The experiment on the control of *Tmolus* damage to pineapples is not conclusive, because of the lack of statistical significance. However, the results are believed to be of sufficient value to warrant tentative suggestions being made for controlling the pest in question, and for indicating lines along which further experiments should be carried out.

Applications of Derrimac dust should be commenced as soon as the inflorescence is visible. The dusting should then continue at fortnightly intervals until the fruit is ready for picking.

Further experiments should be undertaken to determine the maximum interval between dustings which will still prevent the damage to the fruit by larvae of *Tmolus*. Considering the apparent advantage of the dust as opposed to the spray, it hardly seems worth while continuing further experiments with Derrisol.

The efficiency of the insecticide applications cannot be established definitely from this experiment. The results nevertheless indicate that Derrimac reduced the amount of caterpillar damage and there was little to choose between the weekly and fortnightly dustings.

Summary.

1. An experiment is described in which derris preparations were used in an attempt to control the injury to pineapple fruits by *Tmolus echion*.

2. Plots were demarcated in a pineapple plantation and five treatments were compared in a randomized block lay-out.

3. The experimental treatments were as follows:
   (*a*) Control;
   (*b*) Derrimac powder dusted on the fruits at weekly intervals;
   (*c*) Derrimac similarly applied fortnightly;
   (*d*) Derrisol (1 oz. to 3 gallons of water) sprayed on the fruits once a week;
   (*e*) Derrisol similarly applied fortnightly.

4. Statistical analysis of the results showed that in no case was the difference between any two treatments significant.

5. The results suggest that some control of *Tmolus* attack is achieved by using Derrimac dust at intervals of a fortnight.

Acknowledgments.

Our grateful thanks are due to Mr. Graham for permitting the use of the pineapple plants in his plantation for this experiment.

The routine applications of the insecticides have been carried out under the supervision of Mr. J. R. Foster, whose assistance is gratefully acknowledged.

Reference.

1. Harris, W. Victor.—On a Lycaenid Butterfly attacking pineapples in Trinidad, B. W. I., *Bulletin of Entomological Research* 18, Part 2, pp. 183-188, 1927.

THE CHEMICAL COMPOSITION OF THE HEN'S EGG.*

The hen's egg is one of our most valuable "protective" foods; except for the milch cow, the hen's efficiency as a converter of raw materials into human foodstuffs is greater than that of any other farm animal. An averaged-sized egg weighs approximately 2 oz., of which the shell comprises 11 per cent., the white 58 per cent., and the yolk 31 per cent. The percentage composition of the edible portion of the egg is as follows:

Whole egg: edible portion.

Water	....	73.7 %
Protein	....	13.4 %
Fat	....	10.5 %
Ash	....	1.0 %

White of egg contains a high proportion of water, and its main organic component is protein. Small amounts of salts are also present, along with traces of fat and about one-half of one per cent. of carbohydrate.

Composition of egg white.

Water	....	....	87.77 %
Protein	....	....	10.00 %
Fat	....	....	0.05 %
Ash	....	....	0.82 %

The yolk differs greatly in composition from the white; it contains much less water and more solid materials, among the latter being a large proportion of fat. It is also well fortified with vitamins and mineral substances.

Composition of fresh yolk.

Water	....	....	49.0 %
Protein	....	....	16.7%
Fat	....	....	31.6 %
Ash	....	....	1.5 %

The chief colouring matter of the yolk is xanthophyll, a pigment which is present in yellow maize and green plants. The depth of colour is roughly proportional to the xanthophyll content which is regulated mainly by the nature of the hen's diet.

Protein Content of White and Yolk.

Protein Content of the white.—Egg white or egg albumin is not a single substance, but is made up of five different proteins of which one, ovalbumin, comprises about 70 per cent. of the total. All the nutritionally essential amino-acids occur in the proteins of egg white.

Protein Content of the yolk.—The protein content of the yolk is relatively high, and is composed mainly of the two proteins, vitellin and levitin. Vitellin belongs to the group of proteins which contain phosphorus, the phosphoproteins, whereas levitin contains little phosphorus, but has a relatively high percentage of sulphur.

Fat Content of the yolk.—All the fat of the egg, excepting traces that occur in the white, is concentrated in the yolk, where it is present in the form of an emulsion. The fats of the egg consist of two types: (1) neutral fats or glycerides, and (2) phosphorized fats or lecithins. The neutral fats are of the type found in beef, mutton and other body-fats. The lecithins contain, in addition to fatty acids, both nitrogen and phosphorus, and are present in the yolk to the extent of probably 10 per cent.; the hen's egg, therefore, is richer in this respect than most of the other fats usually present in the human diet. There is reason to believe that the lecithins are of considerable importance in fat metabolism; they are probably essential for the normal structure and functioning of the human body.

Another component of the yolk is cholesterol, the presence of which is important because it is closely associated with vitamin D.

Mineral Content of white and yolk.

The more important minerals and their distribution in the egg are as follows:—

	Whole egg.	Egg yolk.	Egg white.
Calcium (per cent.) ...	0.06	0.13	0.01
Chlorine (per cent.) ...	0.13	0.10	0.15
Copper (parts per million)	1.87	4.15	0.85
Iodine (parts per million)	0.1	—	—
Iron (per cent.) ...	0.003	0.0086	0.0001
Magnesium (per cent.) ...	0.05	0.13	0.01
Manganese (parts per million)	0.33	1.13	—
Phosphorus (per cent.) ...	0.22	0.59	0.10
Potassium (per cent.) ...	0.14	0.11	0.16
Sodium (per cent.) ...	0.13	0.07	0.16
Sulphur (per cent.) ...	0.183	0.157	0.196

The amount of mineral material in the white is relatively small, whereas the yolk is qualitatively complete with regard to its mineral content, *i.e.* it contains all the elements necessary for the formation of blood, bone, and soft tissues of the animal body. The yolk, compared with other foods, is relatively rich in iron compounds, which appear to be in a form that is easily assimilated and utilized.

Vitamin Content of White and Yolk.

Vitamin Content of the white.—The white is not a source of vitamins, except with respect to one member of the vitamin-B complex. What was formerly known as vitamin-B is really a mixture of several vitamins, of which only two, namely, vitamin-B1 and riboflavin need be mentioned here. The white of the egg is noteworthy in that it contains little or no vitamin-B1, but it has a relatively high content of riboflavin, considerably more than is found in many other foods, so that egg white is a valuable source of this food factor.

* Abridged version of an article entitled "The Chemical Composition of the Egg", by Dr. E. M. Cruickshank which appeared in *Chemistry and Industry*, Vol. 59, No. 24.

Vitamin Content of the yolk.—The vitamin-A content of the yolk is high, but it is a variable quantity (normal values range from 200 to 800 International Units per egg), and is influenced by dietary and physiological factors. The yolk is also rich in vitamin-D, and is second only to certain fish oils as a natural food-source of this vitamin. One egg yolk may contain 10 to 50 International Units of vitamin-D, the amount present depending on the diet and the environmental conditions under which the eggs are produced. Vitamin-B in the hen's egg is confined to the yolk, which also contains a rather larger amount of riboflavin per unit weight than the white.

Effect of Diet and Composition.

Recent research has shown that variations in the chemical composition, vitamin content and hatchability of the egg may be brought about by appropriate diets. Egg size is fundamentally an inherited characteristic, but both the taste of the egg and the colour of the yolk are influenced by the food consumed. Onion tops, rape, turnips or fishmeal, if fed in too large amounts, will impart an unpleasant flavour to the yolk. Hens kept in confinement and fed on cereals (such as oats, wheat and their by-products) will lay eggs having pale-coloured yolks, but the colour rapidly darkens when the hens are allowed access to grass, or are fed yellow maize, dried alfalfa, or other xanthophyll-containing foods.

One of the components of the hen's egg which is markedly affected by the diet is egg fat. The actual amount present can probably be influenced only to a minor extent, but the chemical composition may be greatly altered according to the type of fat that is fed in the ration.

The vitamin-A content of hen-food will modify appreciably the vitamin-A content of the egg. If the ration is low in vitamin-A, the eggs produced will contain only a small amount of this vitamin, but the addition of 2 per cent. of cod-liver oil to such a ration will bring about a fivefold increase in vitamin-A content of the egg. Allowing the hens access to pasture has a similar effect. The use of yellow maize and dried alfalfa also results in the production of eggs rich in vitamin-A. By feeding large amounts of cod-liver oil, or administering a vitamin-A concentrate, it is possible to increase the vitamin-A content considerably above the normal, but there appears to be a limit to the amount of this vitamin which the hen will transfer to the egg, and the proportion transferred decreases rapidly as the intake increases.

The vitamin-D content of the egg is dependent on the sources of vitamin-D available to the hen. When hens are kept in confinement, vitamin-D is usually supplied in the form of cod-liver oil. When they are on free range, they are independent of dietary supplies of the vitamin, since their requirements are met by the action of the ultra-violet rays of the sun on the body. Hens having access to grass pasture (and therefore to sunlight) will produce eggs ten times as rich in this vitamin as eggs from hens on the same ration but confined indoors. Moreover, while there is only a limited transfer of vitamin-A from the food to the egg, vitamin-D does not appear to be restricted in this way. By the feeding of vitamin-D concentrates, extraordinarily high contents may be produced in the yolk. Under experimental conditions, eggs containing about 48,000 I.U. of vitamin-D per yolk (which is over 600 times the normal concentration) have been produced. There is no doubt that the antirachitic value of market eggs differs appreciably in accordance with the methods of feeding and management employed by the producers. Under wartime conditions, economic and other considerations will foster the "extensive" system of poultry husbandry (*i.e.* housing the birds so that they have freedom to range over grassland), with a resultant beneficial effect on the vitamin-D content of the eggs.

The amount of vitamin-B1 in the egg is influenced by the diet, but since the rations normally fed to poultry (such as cereals and their by-products) are well supplied with vitamin-B1, the average egg is not likely to be deficient in this vitamin. The riboflavin content of the egg appears to be directly related to the riboflavin content of the food. When supplements, such as casein or meat meal, form the sole source of protein in the ration, the amount of riboflavin in the egg will be small, but it may be raised when protein is supplied in the form of dried skim milk or alfalfa, each of which is an excellent source of riboflavin.

Mineral Content.

There is no experimental evidence to show that the calcium of yolk or white can be modified, but when the calcium in the diet is below the optimum, a thinning of the egg-shell results. The amounts of iron and copper present vary considerably in individual eggs, and it appears that the content of these substances depends on factors other than the amount ingested in the food. On the other hand, the iodine content of the egg is greatly influenced by the iodine intake by the hen. The normal content of iodine can be increased many times over if the element (in the form of potassium iodide) is administered in the drinking water, or if rations containing either organic or inorganic iodine are fed, both these forms apparently being equally available for transfer to the egg.

H. F. Birch.

The Editor requests that any subscriber who fails to receive *Tropical Agriculture* regularly should communicate with him immediately in order that the matter may be rectified.

MISCELLANEOUS NOTES.

Are There Different Critical Oxygen Concentrations for the Different Phases of Root Activity?

The following letter from D. Boynton J. de Villiers and W. Reuther of Cornell University, which appeared in Science Vol. LXXXVIII, No. 2294, p. 569, presents some striking results that have been obtained in studies of the soil-aeration factor in the growth of apple trees, and is well worthy of consideration by investigators of other fruit crops, such as citrus, and cacao.

Recent investigations with apple tree roots under field and greenhouse conditions have indicated that there may be different critical oxygen concentrations for different phases of root activity. (i) *Subsistence.*—Evidence from field studies now in progress indicates that apple tree roots larger than 1 mm. in diameter are able to subsist in soil atmospheres containing less than 0.1 per cent. to 3.0 per cent. oxygen for considerable periods of time when the tree as a whole is in active growth. Controlled greenhouse experiments with apple seedlings (1) point to the probability that when the oxygen in the soil atmosphere is maintained at 3 per cent., the roots are at a "subsistence level" with respect to oxygen, that is, they continue to live but grow slowly if at all. At oxygen pressures below 1 per cent. they seem actually to lose weight. This "subsistence level" probably coincides with the lower critical concentration as defined by Cannon (2). (ii) *Initiation of new roots.*—Recently Dr. H. B. Tukey and Dr. K. D. Brase (3) have found that, during wet years, newly planted apple trees have produced larger root systems and tops when German granulated peat moss has been incorporated with the soil in the tree hole than when topsoil alone was used. During dry years there was little or no beneficial effect from the peat. Through the courtesy of Dr. Tukey, analyses of soil gases in boxes containing newly planted apple trees, kept under controlled conditions, were made by the authors at the Geneva Agricultural Experiment Station, New York State, U.S.A., and present a possible explanation of this situation, namely, that a high oxygen level may be necessary for initiation of new roots from an existing root system. In this case, a soil atmosphere containing about 12 per cent. oxygen appeared to reduce the size of the root systems and tops considerably. (iii) *Growth of existing root tips.*—Normal growth of existing root tips occurs at the upper critical concentration of oxygen, as defined by Cannon. The greenhouse study with apple seedlings indicates that normal growth does not occur at oxygen concentrations below 10 per cent., even though there may be considerable growth at percentages between 5 per cent. and 10 per cent. (iv) *Absorption and accumulation.*—The experiments of Dr. D. R. Hoagland and Dr. T. C. Broyer (4) have emphasized the dependence of the processes resulting in absorption and accumulation on aeration. In this connection, it is noted that the ash content (as percentage dry weight) of apple seedlings grown at different oxygen pressures decreased uniformly as the oxygen percentage was decreased below 15 per cent. Since the dry weight of the root tissue was less at oxygen percentages below 10 per cent., it is probable that absorption and accumulation were inhibited at oxygen pressures below 10 per cent. This happens to coincide with the apparent upper critical concentration and may mean that maximum accumulation occurs at the upper critical concentration of oxygen.

References.

(1) J. de Villiers. Unpublished data.
(2) William Austin Cannon, *Carnegie Inst. Wash. Pub.* 368, 1925.
(3) H. B. Tukey and K. D. Brase, *N. Y. State (Geneva) Agric. Expt. Sta. Bull.* 682, 1938.
(4) D. R. Hoagland and T. C. Broyer, *Plant Phys.*, 11: 471-507, 1936.

* * *

Diet and Health in Rhodesia.

Lord Bledisloe has recently described some very interesting experiments in the feeding of native labour that have been conducted by the Rhokana Copper Company during the last three years. These have shown the advantage socially and commercially of providing natives engaged in hard manual toil with a properly balanced ration containing an adequate proportion of protein, in the form of animal flesh, as well as enough fruit and vegetables to supply the requisite vitamins and minerals. The experiments are still in progress. The average African worker lives on starchy foods such as maize, millet, or cassava and has a working efficiency only about half that of an average white man engaged on similar work; his susceptibility to disease is at least three times as great. The Rhokana natives engaged in copper mining have a capacity for work and for resisting disease from 60 to 100 per cent. higher than their wholly starch-fed native compatriots. This valuable experiment has proved to be a thoroughly sound economic proposition. An effort is also being made to make the starved land more fertile by treatment with a compost-produced humus.—(*Chem. & Ind.*, Vol. LIX, No. 8, p. 120, 1940.)

* * *

Manuring of Rubber. Rubber Research Institute of Malaya.

Striking increases in growth and yield have been obtained by the regular application of a complete manure to rubber trees of the Dunlop Malayan Estates, Ltd., when they were brought into tapping 10 years ago, being then 7 years old. The increased yield over comparably unmanured trees was 30 per cent. or 200 lb. per acre. The question of whether nitrogen alone would produce adequate results is still unsettled and for the moment the inclusion of phosphate and a little potash is recommended by the Rubber Research Institute.—(*Imp. Bur. of Hort. & Plant. Crops, Hort. Abstracts*, Vol. X, No. 2, Abs. 701, p. 169, 1940.)

CHEMICAL NOTES.

(Compiled by the College Department of Chemistry and Soil Science.)

Softening of Rubber.

Crude raw rubber as received by manufacturers has to be reduced by heating and mechanical working to a soft plastic condition to permit incorporation of the essential compounding ingredients. Experiments have been carried out by V. H. Wentworth and J. D. Hastings at the Rubber Research Institute of Malaya (*J. Rub. Res. Inst. Malaya*, 9, Comm. 236 and 237), to determine if softening could not be more economically effected by modifying the preparation of the rubber on the plantation. A promising line of attack is the treatment of latex prior to coagulation with substances such as zinc soaps which bring about softening in the course of the normal smoking and drying processes. Pine tar is an effective softener in common use, and in view of the fact that it was found possible to incorporate large quantities into the latex, it is suggested that master-batch preparation on estates might be worthy of consideration by the manufacturers. The incorporation of emulsions of 'peptizing agents' into the latex in the pre-coagulation stage is another method which has been used during the last two years for softening purposes. It is now shown that the degree of softness achieved depends to a large extent on the temperature at which the wet sheet is afterwards dried, high temperature in the early stages assisting softening markedly.—(*Nature*, Vol. 145, No. 3662, 1940.)

* * *

Recent Investigations on Pectins.

An outstanding property of a pectin is that it shall form a sugar-acid jelly under certain well-defined conditions. It now seems probable that many of the pectins described in literature would not be capable of forming such a jelly. The relation between chemical composition and jelly strength or viscosity has been shown to be very slight. A high content of uronic acid generally connotes satisfactory jelly strength, but methoxyl content is no criterion, and in many cases can be shown to have no relation to jelly strength. On the other hand, the method of preparation is one of the most important factors affecting jelly strength ; the employment of high temperatures and pressures, as obtained in the autoclave for example, invariably inhibits jelly formation. A close relationship exists between the viscosity of pectin solutions and jelly strength, which accordingly is believed to depend mainly on molecular size, as indicated by viscosity. Indeed, recent authorities consider that jelly strength and viscosity of solution of pectins are functions of molecular chain length.

The nature of the pectic acid chain of galacturonic acid units is now definitely established. During treatment with 12 per cent. hydrochloric acid in the standard chemical analysis of pectins, carbon-dioxide liberated by the decomposition of uronic acid groups is evolved rapidly, the evolution showing a sharp peak at 20 to 30 minutes from the time that boiling is begun, and 50 per cent. of the total carbon-dioxide is given off in the first hour. This behaviour is different from that of hexoses and poly-saccharides that do not contain uronic acid groups ; these show no such peak, the evolution of carbon-dioxide being small and maintained at a low level for many hours. It is considered that observations on the rate of evolution of the gas during acid decomposition may furnish an indication of the occurence of uronic acid groups in poly-saccharides containing such groups in small amount.—(F. W. Norris, *Annual Reports on the Progress of Chemistry ;* Chemical Society of London, Vol. XXXVI, p. 379, 1939.)

* * *

Nitrogen Fixation by Algae.

A recent contribution to the problem of nitrogen fixation by blue-green algae has been made by P. K. Dey in "The Rôle of Blue-Green Algae in Nitrogen Fixation in Rice-Fields"*. The author isolated from an Indian soil sample five species of *Anabaena* and *Phormidium faveolarum* in uni-algal culture. By repeated subculturing on sterilized silica-gel plates, three species of *Anabaena* and *Phormidium faveolarum* were obtained in pure bacteria-free cultures. After incubation for 60 days in nitrogen-free solution, three species of *Anabaena* exhibited considerable increase in nitrogen, and such nitrogen fixation was stimulated by the addition of small amounts of soil extracts. *Phormidium faveolarum*, on the other hand, afforded no evidence of nitrogen fixation. A considerable part of the nitrogen fixed is found in the external medium in organic form. In discussing the possibility of nitrogen-fixing algae affording conditions favourable for activities of nitrogen-fixing bacteria, experiments were carried out first with the alga alone, second with alga plus *Azotobacter*, and third with *Azotobacter* alone. After incubation for two months, no fixation of nitrogen was found in cultures containing *Azotobacter* only. The amount of nitrogen fixed by the mixed cultures did not differ from that in the cultures containing the alga alone. No evidence was suggested that products of decomposition of algae serve as a source of energy for the nitrogen-fixing bacteria. The author concludes that algae can grow and fix nitrogen in the soil independently of bacteria or fungi, and that algae are the main agents of nitrogen fixation in the rice fields.—(*News Edition, American Chemical Society*, Vol. 18, No. 7, pp. 313-314, 1940.)

* *Proc. Roy. Soc.*, B127, 121 (1939).